

Marine
Laboratory
Aberdeen

SCOTTISH FISH FARMS
Annual Production Survey 1996

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FOREWORD

The annual production survey of fish farms in Scotland for 1996 was carried out on behalf of the Scottish Office by the Marine Laboratory Aberdeen. The Marine Laboratory Aberdeen is the official reference source for data in this report. As from April 1996 Fisheries Research Services (FRS) was established as an Executive agency within the Scottish Office and the Marine Laboratory Aberdeen designated an operational unit within the agency.

Responses from Scottish rainbow trout and Atlantic salmon farming companies to Marine Laboratory Aberdeen questionnaires covering the period January-December 1996 are summarised in this Report. Copies of the questionnaires are included in Appendix I(a-c). The Report is structured to allow readers to follow trends within the trout and salmon industries in addition to providing information on the latest production year. Where available statistics are given for the 10-year period 1987-1996. Data from previous years have been reassessed and updated where necessary. The regional production information given in this Report relates to Scottish Local Government Regions prior to their reorganisation in 1996.

To determine the role of brown trout culture in Scotland farmers were requested to supply specific data on this species. An analysis of the findings is included in this Report.

Under the Registration of Fish Farming and Shellfish Farming Business Order 1985 all companies engaged in fish farming in Scotland are required to register with SOAEFD. The registers are maintained by the Fish Health Inspectorate based at the Marine Laboratory, Aberdeen. The contents of the registers cannot be made public (Diseases of Fish Act 1937 as amended), however company and site information can be published in summary form and these are shown in the appropriate tables. Due to the small numbers of farms culturing other species in Scotland eg. turbot, charr, tilapia and eels it is not possible to record details of production without identifying the sources of information.

In 1992 Great Britain was granted Approved Health Zone Status with respect to viral haemorrhagic septicaemia (VHS) and infectious haematopoietic necrosis (IHN) viruses in accordance with EC Directive 91/67/EEC and EC Decision 92/538/EC. In July 1996 further health protection measures were achieved with respect to the ectoparasite *Gyrodactylus salaris* in EC Decision 96/490/EC. These Decisions allow GB to maintain the current high health status in stocks of wild and farmed fish by banning imports of fish from zones of lesser health status.

An amendment to UK legislation, titled The Deregulation (Salmon Fisheries [Scotland] Act, 1868) Order 1996, came into effect in May 1996. This Order permits the sale of farmed salmon ova for human consumption (salmon caviar). There were no records of salmon ova having been sold under this Order in 1996.

An outbreak of Viral Haemorrhagic Septicaemia (VHS) on a land based turbot farm using pumped ashore seawater on the island of Gigha was reported in 1994. This outbreak was contained, the infection eradicated and the farm cleansed and disinfected. No other farms were found to be infected. The island of Gigha was subsequently removed from the GB Approved Health Zone. A programme to re-instate the VHS free status of Gigha has been approved by the Commission (EC Decision 97/185/EC). Since 1994 possible sources of infection in the marine environment have been investigated both by the Marine Laboratory and by ICES, covering 10 common fish species and extending from northern Norway to the Bay of Biscay. To date rhabdoviruses resembling VHS virus have been identified in cod, haddock and herring. Investigations are continuing and results will be published when available.

The cooperation of the fish farming industry in completing the questionnaires is gratefully acknowledged.

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SUMMARY

The principal contents of this Report are presented in summary format below. For detail and additional information on production, including time series data, the reader is referred to the specific Sections and Tables in the Report.

RAINBOW TROUT

		1996	1995	% Difference
No. ova laid down to hatch	(million)	22.7	20.8	+ 9
Number of ova imported	(million)	21.3	20.3	+ 5
Total production	(tonnes)	4,630	4,683	- 1
Production for the table	(tonnes)	3,884	4,084	- 5
Production for restocking	(tonnes)	746	599	+25
Number of staff employed		189	196	- 5
Mean productivity	(tonnes/man)	24.5	23.9	+ 3

In 1996 production in Rainbow trout decreased by 53 tonnes. Seven fewer staff were employed but mean productivity per man increased to 24.5 tonnes per year. The numbers of ova laid down to hatch and imported in 1996 increased by 1.9 and 1.0 million respectively, these fish will contribute to the 1997 harvest.

BROWN TROUT

Brown trout were grown on a small but significant number of registered fish farms, commonly in association with rainbow trout. Approximately 2 million ova were produced giving rise to 0.9 million fingerlings. Production was primarily directed at restocking rivers and recreational fishing ponds/lochs but an estimated 5 tonnes was produced as trout or sea trout for the table trade. There was a small cross border trade in ova, fingerlings and fish between Scotland and England.

ATLANTIC SALMON

SMOLTS

		1996	1995	% Difference
No. ova produced	(million)	122.7	89.6	+ 37
No. ova laid down to hatch	(million)	78.4	64.9	+ 21
No. ova exported	(million)	42.3	25.5	+ 66
No. ova imported	(million)	8.0	2.1	+381
No. smolts produced	(million)	33.6	26.5	+ 27
No. smolts put to sea	(million)	32.9	26.8	+ 23
Number of staff employed		441	396	+ 11
Productivity (thousand smolts/man)		76.2	67.0	+ 14

PRODUCTION FISH

Total production	(tonnes)	83,121	70,060	+ 19
Production of 0-year fish	(tonnes)	638	369	+ 73
Production of grilse	(tonnes)	25,776	22,235	+ 16
Production of pre-salmon	(tonnes)	32,222	25,540	+ 26
Production of salmon	(tonnes)	24,485	21,916	+ 12
Mean fish weight 0-year	(kgs)	2.0	1.8	+ 11
Mean fish weight grilse	(kgs)	3.0	2.9	+ 3
Mean fish weight presalmon	(kgs)	3.8	3.8	0
Mean fish weight salmon	(kgs)	4.5	4.3	+ 5
Number of staff employed		1,391	1,355	+ 3
Mean productivity (tonnes/man)		60	52	+ 15

SMOLT SURVIVAL (% harvested)

Smolt year class	Survival year 1	Survival year 2	Total survival
1993 input year class	65.5	25.0	90.5
1994 input year class	66.9	24.6	91.5

There were significant increases in production in Atlantic salmon both of smolts and production fish. Ova production and ova laid down to hatch in 1996 increased by 33.1 and 13.5 million respectively and should result in increased smolt production in 1997. Exports of salmon ova increased by 16.8 million whilst imports increased by 5.9 million. Some 7 million more smolts were produced in 1996 and should contribute to a higher production tonnage of salmon in 1997. These data refer specifically to salmon production and do not take into account any marketing or other economic factors which may influence the industry.

RAINBOW TROUT

(*Oncorhynchus mykiss*)

Annual production survey questionnaires were sent to all 52 companies registered with the marine Laboratory Aberdeen as actively engaged in the production of rainbow trout in Scotland in 1996. A return was received from all the companies and information obtained covering all 69 sites currently in production.

Production

TABLE 1a
Total production (tonnes) of rainbow trout in 1987-1996

Year	Tonnes	Year	Tonnes
1987	3,207	1992	3,953
1988	3,556	1993	4,023
1989	3,512	1994	4,263
1990	3,183	1995	4,683
1991	3,334	1996	4,630

TABLE 1b
Production (tonnes) for the table trade in 1992-1996

Year	<450 <1 lb	450-900g 1-2 lbs	> 900g >2 lbs	Total tonnes
1992	2,666	144	645	3,455
1993	2,481	272	764	3,517
1994	2,376	288	1,038	3,702
1995	2,736	199	1,149	4,084
1996	2,701	181	1,002	3,884

TABLE 1c
Production (tonnes) for the restocking trade in 1992-1996

Year	<450 <1 lb	450-900g 1-2 lbs	>900g >2lbs	Total tonnes
1992	187	256	55	498
1993	124	346	36	506
1994	125	337	99	561
1995	107	411	81	599
1996	188	484	74	746

Production was directed entirely at the UK table and restocking trades. In 1996 total production decreased by 53 tonnes (1%) compared with 1995 and was due principally a) to poor survival of fry in summer 1995 when water temperatures were unusually high and flow rates and oxygen availability subsequently low and b) to slow growth rates in the following winter when unusually low water temperatures prevailed for a prolonged period. Production has tended to be market driven and any future increase in production is likely only if additional market outlets can be established and assuming that relative freedom from disease is maintained.

Production for the table trade decreased by 200 tonnes (5%). Demand was principally for portion size fish weighing <450g/<1lb and this size group comprised 58% of the total production. There was significant demand for large fish weighing <900g/2lbs and this size group comprised 22% of production. As in previous years the outlet for large fish was primarily for smoking.

Production for the restocking trade increased by 147 tonnes (25%). The restocking of fishing ponds, lochs and resevoirs for recreational angling has become increasingly important to the industry and accounted for 16% of production in 1996 (13% in 1995). It should be noted that recreational fisheries were not classed as fish farms and that the figures given in the Report refer to stocking tonnages and not to catches taken by anglers.

Production by Site

TABLE 2a
Numbers of sites grouped by tonnage produced in 1992-1996

Year	Number of sites per production tonnage				Total Number of sites
	<1-25	26-100	100-200	>200	
1992	30	12	10	6	58
1993	28	13	11	5	57
1994	25	15	12	4	56
1995	26	15	13	5	59
1996	24	14	12	6	56

Production tonnages were reported from 56 grower sites whilst another 3 sites reported an input of stock in 1996. It is expected that these sites will yield production tonnages in 1997.

Since 1992 the number of sites in the 1-25 tonnes production range has decreased whereas the number of sites in the 26-100 and 101-200 tonnes production ranges has increased. The movement to increase onsite production is a reflection of the prevailing economics within the industry.

Production by Method

TABLE 2b
Grouping of rainbow trout farms by production tonnages by the main methods of production in 1996 and comparison with production in 1995.

Production method	Production grouping (tonnes) in 1996					Total tonnage & (%) by method		No.* of sites	
	<10	10-25	26-50	51-100	>100	1995	1996	1995	1996
FW cages	1	2	0	1	6	2,058 (44)	1,766 (38)	13	10
FW ponds & raceways	2	4	3	3	7	1,512 (32)	1,560 (34)	18	19
FW tanks & hatcheries	7	7	2	3	2	679 (15)	657 (14)	23	23
SW cages	0	1	1	1	3	432 (9)	647 (14)	5	6
Total	10	14	6	8	18	4,683	4,630	59	56

* Excludes sites which specialised in the production of ova, fry and/or fingerlings for on-growing.

Production was principally in freshwater (86%) with the remainder (14%) being produced in seawater. The main rearing systems were cages, ponds and raceways. Production in freshwater cages decreased by 292 tonnes (14%) compared with 1995 whilst freshwater production by other methods remained relatively constant. Seawater production increased by 215 tonnes (50%) in 1996.

A number of types of rearing facility, ranging from hatchery units to tanks, ponds, raceways and cages, may be present on a site and some sites are capable of rearing from egg through to adult fish. Depending on the company's growing strategy only certain facilities may be employed at any given time. The numbers of sites and type of facility available in 1996 was:

Hatchery units	25 sites
Ponds & Raceways	36
Tanks	39
Freshwater cages	13
Seawater cages/raceways	7

Not all of the above facilities were in use .

Company and Site Data

TABLE 3
Number of companies and sites in production during 1990-1996

Year	No of companies	No of sites
1990	59	71
1991	56	69
1992	53	72
1993	52	74
1994	56	72
1995	54	69
1996	52	69

The number of companies registered with the Marine Laboratory Aberdeen as actively engaged in rainbow trout production was 52, a decrease of 2 on 1995. The number of sites registered as holding rainbow trout was 103; of these 80 were classed as Active and 23 as Inactive. Of the active sites only 69 produced in 1996.

Although companies may cease to operate actual sites retain the potential for future use. Inactive sites may be restocked at some later date, when their status will revert to Active. This accounted for the numbers of sites in production in 1995 and 1996 being the same despite there being 2 fewer operating companies in 1996.

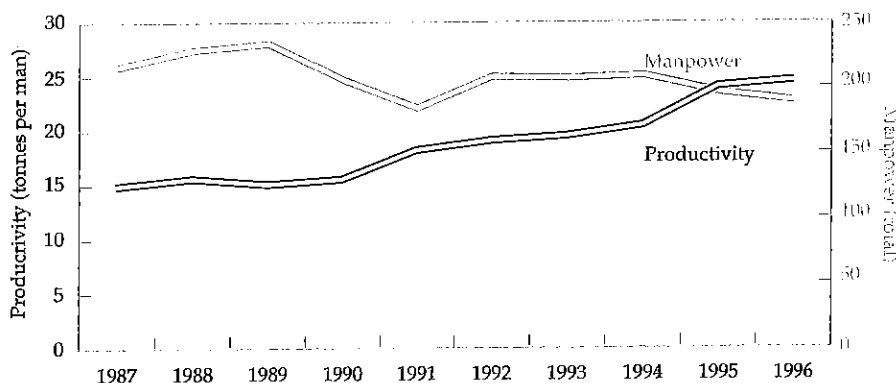
Staffing and Productivity

TABLE 4
Number of staff employed and productivity per man in 1990-1996

Year	Full-time	Part-time	Total	Productivity (tonnes/man)
1990	138	68	206	15.45
1991	133	51	184	18.12
1992	135	73	208	19.00
1993	134	73	207	19.43
1994	139	70	209	20.40
1995	132	64	196	23.89
1996	129	60	189	24.50

The total number of staff employed in rainbow trout production in 1996 was 189, a decrease of 7 on the 1995 figure, and continued the downward trend in the numbers of both full-time and part-time employees evident since 1994. The decrease in staff numbers in 1996 was due to 2 companies ceasing operations and to other efficiencies within the industry. Productivity, measured as tonnes produced per man, increased by 3% in 1996 compared with 1995 and was achieved despite relatively poor growing conditions experienced during the year. No distinction was made between full and part-time staff in calculating productivity. Productivity is likely to increase in future as industry introduces further automation and mechanisation and feedstuffs and husbandry practices continue to improve. Increases in production will be achieved only if additional market outlets can be established.

Manpower and productivity in rainbow trout production 1987-1996



Production by Region

The regional production information given in this Report relates to Scottish Local Government Regions prior to their reorganisation in 1996.

TABLE 5
Staffing, production, fry & fingerling trade and number of fish vaccinated by Region in 1996

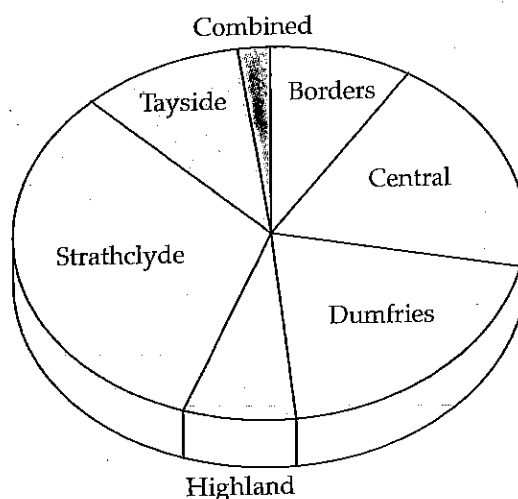
Region	Staff		Production tonnage		No. (000s) fry and fingerlings		No (000s) fish vaccinated
	F/T	P/T ted	Table	Restock	Bought	Sold	
Borders	10	4	326	83	1,024	-	1,604
Central	18	7	736	136	2,982	-	2,782
Dumfries and Galloway	25	8	800	137	1,846	2,373	1,700
Highland	9	5	264	59	1,284	165	1,284
Strathclyde	45	16	1352	151	2,689	1,235	2,574
Tayside	14	8	362	110	3,317	7,805	6,345
Combined* Regions	8	12	44	70	120	-	120
All Scotland	129	60	3884	746	13,262	11,578	16,409

*Combined include Lothian, Fife, Grampian and Western Isles Regions

Strathclyde, followed by Dumfries & Galloway and Central, continued to be the dominant Regions with regard to the numbers of staff employed and the tonnages produced for the table trade. Production for restocking was more evenly spread throughout the Regions but tended to reflect the location of the production sites in relation to the main centres of population and local demand by angling enthusiasts.

Production and trade in fry and fingerlings tended to be concentrated in Tayside Region and to a lesser degree in Dumfries & Galloway and Strathclyde Regions. The trade in fry & fingerlings demonstrated the local importance of hatchery and juvenile rearing units, which in turn supply stock to other sites for ongrowing. Vaccination was widely used in all Regions.

Proportion (%) production by Region in 1996



Ova Laid Down

TABLE 6
Number (000s) and sources of ova laid down to hatch in 1993-1996

Year	GB broodstock			Non-GB broodstock			Grand total
	Own stock	Other GB stock	Total GB	Northern hemisphere	Southern hemisphere	Total foreign	
1993	1,830	405	2,235	12,815	4,694	17,509	19,744
1994	479	625	1,104	13,055	5,445	18,500	19,604
1995	165	360	525	12,485	7,825	20,310	20,835
1996	420	988	1,408	13,247	8,023	21,270	22,678

In 1996 the number of eyed ova laid down to hatch was 1.8 million (6%) greater than in 1995, continuing the upward trend evident since 1994. This indicated a high level of confidence in the industry and increased production tonnages can be expected in 1997.

The dependency by industry on supplies of ova from outwith the GB Approved Health Zone (94%) was again evident although increases in the quantity of ova originating from farmers own and other GB broodstock were reported. A breakdown of imports from northern and southern hemisphere sources is given in the next section. An ongoing concern for the industry is its reliance on a small number of specialist ova producers and possible ova shortages should any of these producers encounter disease or other production problems.

Type of ova

TABLE 7
Number(000s) and proportions(%) of ova types laid down for hatching in 1992-1996

Year	Total ova	All female diploid Nos (%)	Triploid Nos (%)	Mixed sex diploid Nos (%)
1992	21,408	18,099 (85)	796 (4)	2,513 (12)
1993	19,744	17,261 (87)	1,396 (7)	1,087 (6)
1994	19,604	18,105 (92)	1,134 (6)	365 (2)
1995	20,835	19,546 (94)	1,170 (6)	119 (+)
1996	22,678	21,308 (94)	935 (4)	435 (2)

The preference in recent years for all female diploid stock was evident again in 1996 when this stock type accounted for 94% of ova laid down to hatch. The small number of triploid ova laid down was due to production being directed principally towards the table trade where demand was predominantly for small, young fish weighing <450g(<1lb) and there was little requirement to rear large triploid fish. For the restocking trade there is some advantage in producing large non-breeding triploid fish and the extra costs and effort involved in their production may be justified.

Imports of Ova

TABLE 8a
Number and source of ova imported into Scotland in 1994-1996

Source	Number (000s) of ova imported		
	1994	1995	1996
Northern Ireland	6,255	6,285	4,095
Isle of Man	2,950	3,550	4,182
Denmark	3,850	2,650	5,075
South Africa	5,445	7,825	8,023
Others (EU)	-	-	220
Totals	18,500	20,310	21,595

TABLE 8b
Seasonal variation in number (000s) and sources of ova imported in 1996

Month	Northern Ireland	Isle of Man	Denmark	Others (N. hemisphere)	South Africa
January	1,480 (6)	-	-	-	-
February	350 (2)	1,500 (3)	600 (1)	-	-
March	720 (4)	-	600 (3)	-	-
April	470 (5)	30 (1)	750 (3)	100 (1)	-
May	150 (2)	-	2,600 (3)	-	-
June	-	-	-	-	700 (2)
July	-	-	525 (1)	-	3,700 (8)
August	325 (2)	-	-	-	3,573 (8)
September	600 (3)	-	-	-	50 (1)
October	-	52 (2)	-	-	-
November	-	500 (1)	-	120 (1)	-
December	-	2,100 (3)	-	-	-
Totals	4,095(24)	4,182 (10)	5,075(11)	220 (2)	8,023 (19)

In addition to the above rainbow trout imports included a quantity of milt, plus 306,000 fingerlings, from Northern Ireland sources.

The major overseas sources of ova were Northern Ireland, Isle of Man, Denmark and South Africa. Imports from Northern Ireland decreased by 2.2 million (35%) due to local supply problems. Compensatory increases in supply were made from Denmark and the Isle of Man. Ova originating from southern hemisphere sources are 6-months out of phase with those from northern hemisphere sources and by using ova from both sources farmers can, with careful husbandry, regulate growth to produce a constant supply of fish to meet particular market requirements.

Since 1993 movements of live fish, ova and gametes within and into the EU have been controlled by Council Directive 91/67/EEC. Northern Ireland, Isle of Man, the Republic of Ireland and parts of Denmark have achieved Approved Health Zone Status similar to GB in respect of IHN and VHS viruses. In addition a limited number of farms on mainland Europe have also been granted Approved Health Status. Companies wishing to import ova from Approved EU Member States, or Approved farms, MUST give PRIOR NOTICE of any shipment into Scotland to The Marine Laboratory Aberdeen. No imports of a commercial nature are permitted from EU Member States or farms not having Approved Health Status. Imports from Third Countries such as South Africa are only permitted under licence and following rigorous testing by the official authorities in the originating country.

Trade in fry and fingerlings

TABLE 9
Trade in numbers (000s) of fry and fingerlings* bought and sold in 1992-1996

Year	Fry and fingerlings bought(000s)			Total number bought	Total number sold
	All female diploids Nos. (%)	Triploid Nos. (%)	Mixed sex diploids Nos. (%)		
1992	8,993 (84%)	617 (6%)	1,101 (9%)	10,711	10,447
1993	8,395 (73%)	917 (8%)	2,239 (19%)	11,551	9,823
1994	9,854 (90%)	1,017 (9%)	47 (+%)	10,918	10,379
1995	12,449 (95%)	683 (5%)	0 (0%)	13,132	10,912
1996	12,174 (93%)	572 (4%)	283 (2%)	13,029	11,578

*Includes trade in small fish up to circa 80g.

There was considerable trade in fry and fingerling stages between hatchery/first-grower sites and on-grower sites. The numbers bought were approximately the same as in 1995 whilst there was a modest increase (6%) in the numbers sold. Of the fry and fingerlings bought 93% were all female diploid stock with the remainder being triploid or mixed sex diploids, similar to the pattern in the types of ova laid down to hatch.

The imbalance in trade between the numbers of fry and fingerlings bought and sold was expected as they apply to different sectors within the industry. As in 1995 the demand for parr and fingerlings could not be met from within Scotland and additional supplies were obtained from sources in England, Wales and Northern Ireland.

Use of Vaccines

TABLE 10
Number of sites rearing fish vaccinated against ERM in 1987-1996

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
No. of sites	20	21	21	27	30	33	28	35	31	33

Vaccines continued to be widely used as preventative treatments, in particular against the infectious disease Enteric Redmouth (ERM), caused by the bacterium *Yersinia ruckeri*. Vaccination was generally by bath at the fingerling stage. A total of 16.4 million fish were vaccinated, an increase of 4.6 million on 1995. Nine million fish were bought vaccinated whilst the remaining 7.4 million were vaccinated on the receiving site. The large number of fish vaccinated was indicative of farmers acute awareness of potential losses of stock due to ERM.

In general rainbow trout farmers do not vaccinate their stock against furunculosis as this is not perceived as a major threat to the industry. Indications are, however that farmers would vaccinate against RTFS (Rainbow Trout Fry Syndrome), caused by the bacterium *Flavobacterium psychrophila* and which is a common cause of mortalities particularly in the younger stages, if a suitable vaccine were available.

CONCLUSIONS RAINBOW TROUT

The increase in rainbow trout production recorded over 1992-1995 halted in 1996 when production fell by 1%, the reasons being adverse climatic factors and resultant poor juvenile survival and low growth rates. Portion size fish for the table trade continued to dominate production whilst an increasingly significant proportion was for the restocking trade. Production was predominately in freshwater in cages, tanks and ponds. Overall there was a decrease in the number of staff employed and productivity showed a small increase.

The number of ova imported and the number of ova laid down to hatch both increased. As in previous years most ova originated from outside the GB Health Zone but approximately one third came from within the British Isles. "Out of season" ova from southern hemisphere sources comprised another third whilst other EU countries supplied the remainder. Industry continued to show a distinct preference for all female diploid stock at the expense of mixed diploid or triploid stocks. There was a thriving trade in fry and fingerlings, shortages of supply within GB being met from other sources in the British Isles (Ireland, Northern Ireland and Isle of Man) and via imports from EU sources of equivalent health status to GB. Farmers showed an acute awareness of the potential hazards of infectious diseases with a vast increase in the number of fish being vaccinated.

BROWN TROUT (*Salmo trutta*)

Stocks of brown trout were reported by 15 fish farm companies registered in Scotland. Data was also obtained from 6 of the major trout producing companies in England. One additional Scottish company was known to hold brown trout but refused to provide information and has been omitted in this Report.

TABLE 11
Summarised data on brown trout production and market outlets in 1996.

COMPANY DATA		
No. producing companies		15
No. producing sites		17
No. sites holding only brown trout		5
No. sites holding multiple species		12
No. of staff employed	i) full-time	6
	ii) part-time)	19
PRODUCTION IN SCOTLAND		
No. of sites with broodstock		8
No. of fish stripped		1,537
No. of ova produced (million)		2.03
Mean ova production/fish (sex ratio = 1.1)		2,640
Fry/fingerlings produced		872,465
PRODUCTION FROM OTHER SOURCES		
No. of ova		30,000
Fry & fingerlings		62,000
VACCINATION		
No. fish vaccinated	i) ERM	47,000
	ii) Furunculosis	80,000
MARKET OUTLETS (numbers of fish)		
To restocking in Scotland	i) (<200g/8oz)	556,000
	ii) (>200g/8oz)	109,000
To restocking in England		1,000
To fish farms		7,400
To table trade	i) as brown trout	8,000
	ii) as sea trout	3,959

In 1996 brown trout only were held on 5 sites and in association with other species, primarily rainbow trout, on another 12 sites. Some 25 staff were employed but included a number who were also engaged in rearing rainbow trout. Broodstock were held on 8 sites and supplied a total of 2 million ova from 1,537 fish. Of the 6 English companies included in the survey only 3 reported a trade in ova and fingerlings between Scotland and England. The majority of production was used for restocking rivers and recreational fisheries with small quantities going to fish farms for on-growing and to the table trade. Approximately 4,000 brown trout were reared and sold as sea trout. Less than 1% of fingerlings were vaccinated against ERM or furunculosis and suggested that growers did not consider these diseases to be a major cause for concern but the cost of vaccinating may have also been a contributory factor.

Under regulation 91/67/EEC aquaculture establishments which do not place products on the market are not classed as fish farms. Consequently hatcheries belonging to District Salmon Fishery Boards and angling associations were omitted from the survey. Production from these units is understood to be used primarily for restocking rivers. Total production of brown trout is likely to have been significantly greater than indicated in this survey.

THE ATLANTIC SALMON (*Salmo salar*)

The report on Atlantic salmon (*Salmo salar*) is divided into two sections covering ova and smolt production in freshwater and salmon production in seawater. Response from the industry was excellent and we are pleased to record 100% return from the registered sites.

I. Ova and Smolts

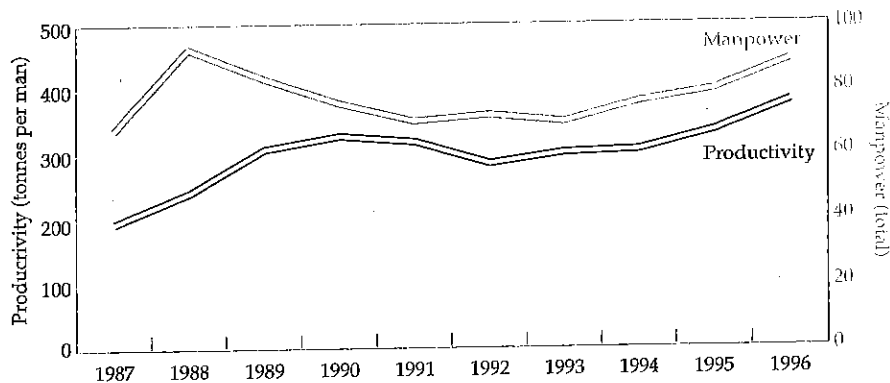
Production and Staffing

TABLE 12
Number(000s) of smolts produced, staff employed and smolt productivity in 1987-1996.

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Number (000s) of smolts produced	13,294	22,499	25,825	24,875	22,404	20,827	21,043	23,117	26,540	33,619
Staffing:										
full-time	248	344	330	285	271	266	233	245	279	308
part-time	90	119	87	93	79	93	115	133	117	133
Total staff	338	463	417	378	350	359	348	378	396	441
Mean Number (000s) of smolts produced per man	39.3	48.6	61.9	65.8	64.0	57.2	60.5	61.2	67.0	76.0

Smolt production in 1996 increased by 7.1 million (27%) to 33.6 million compared with 26.5 million in 1995. The number of staff employed increased by 45 from 396 to 441 and comprised an additional 29 full-time and 16 part-time employees. Productivity, measured as the mean number of smolts produced per man, increased from 67,000 to 76,200, an increase of 9,200 (14%) smolts per man. These combined increases demonstrated a high level of confidence in the smolt sector of the industry. The increase in the numbers of smolts produced can be anticipated to give an increase of a similar order of magnitude in the numbers of salmon harvested in 1997 and 1998.

Manpower and productivity in smolt production in 1987-1996



Smolt by Age Group

TABLE 13
Number of smolts (000s) produced by age group stage in 1992-1996

Year	S ^{1/2}	S1	S1 ^{1/2}	S2	Total
1992	-	20,586	-	707	20,828
1993	686	19,698	202	457	21,043
1994	1,672	20,712	511	222	23,117
1995	2,663	22,705	365	806	26,540
1996	6,298	26,334	523	464	33,619

Production was predominantly directed at S1 smolts and this age group accounted for 78% of production. An increasing number of S^{1/2} smolts have been produced annually since 1993 and in 1996 accounted for 19% of production. Relatively small numbers of S1^{1/2} and S2 smolts were produced and were generally "left overs" or slow growers from the previous year. The additional cost and effort incurred in holding and feeding these older age groups tended to outweigh any advantage they may have had in size or robustness.

Smolts are grouped as S^{1/2}, S1, S1^{1/2} and S2 corresponding to the length of time they spend in freshwater, equivalent to <12, 12-17, 18-23 and =>24 months respectively. By manipulating the length of the photoperiod and the water temperature farmers were able to produce smolts which were physiologically adapted for transfer to seawater at as early an age as 6-months post first feeding. The timing of transfer to sea is not exact and fish may be put to sea as early as October with cohorts possibly transferring any month thereafter. The advantage of using photoperiod adapted smolts in conjunction with normal smolts is that harvest schedules are made more flexible by allowing a better continuous match of fish size with market demand. Early "out of season" smolts may also be produced by selectively grading off the top sizes from normal growing populations.

Company and site data

TABLE 14
Number of production companies and sites in 1992-1996

Year	No of companies	No of sites
1992	74	137
1993	73	138
1994	68	147
1995	69	162
1996	67	166

In 1996 the number of companies registered with the Marine Laboratory Aberdeen as actively engaged in smolt production decreased by 2 to 67. This was due to take-overs and rationalisation within companies and included a number of satellite companies which had been taken over but the new parent company had retained the original company names for business reasons. The overall trend was for smolt production to be under the control of fewer companies.

A total of 224 smolt sites were registered with the Marine Laboratory Aberdeen in 1996. Of these 51 sites were classed as Inactive and 173 as Active, of the latter 166 were in production and 7 were fallow. A number of rearing facilities may be present on a site, each facility being directed at a specific stage or system in smolt production. The facilities may range from egg incubators and troughs for alevins and fry in hatcheries to tanks, raceways and cages for smolts. The number facilities onsite is variable and is dependent on individual company's rearing strategy. The number of sites and type of facility available in 1996 was:

Hatchery	83
Tanks	113
Ponds and raceways	2
Cages	108

Not all of the above facilities were in use.

Production systems

TABLE 15a
Number of smolt production systems and capacity (cubic metres) in 1994-1996

System	No of sites with systems			Total capacity (000s) cubic metres		
	1994	1995	1996	1994	1995	1996
Hatcheries, tanks, ponds and raceways	85	95	93	54	49	48
Cages	62	67	73	276	266	308
Total	147	162	166	330	329	356

TABLE 15b
Number (000s) of smolts produced and stocking densities by production system in 1994-1996

Year	Number of smolts produced (000s)			Stocking densities (smolts/m ³)		
	1994	1995	1996	1994	1995	1996
Tanks	10,873	11,480	15,284	200	234	318
Cages	12,244	15,060	18,335	44	54	59
Total	23,117	26,540	33,619			

Two systems were used to rear smolts, namely tanks (incl. raceways) and cages - the former based on land, the latter in freshwater lochs. In 1996 the number of tank sites in production decreased by 2 whilst the number of cage sites increased by 6. Since 1994 cubic capacity in tanks has decreased by 11% whilst cubic capacity in cages has increased by 8%. The numbers of smolts produced in tanks and cages have both increased with the majority of smolts (55% in 1996) being produced in cages. Stocking densities in tanks are considerably greater than in cages, due principally to producers being able to readily observe their stock and effect any necessary husbandry measures as and when necessary. Such controls are not readily applicable to cages but cages have the advantage in that they are less expensive to operate. Since 1994 stocking densities in terms of smolts produced in both tanks and cages has increased by approximately 50%.

An increasing number of companies have invested in high-tech, high density recirculation production tank units which give considerable control of the rearing environment. These units make efficient use of what may be a limited water supply and are environmentally friendly in that residual particulate waste matter is oxidised and concentrated within the unit for later bulk disposal. By careful husbandry stocking densities in these units can be greatly increased and growth advanced to allow the earlier transfer of parr, or alternatively the production of larger parr, to on-growing cage or tank systems. Also by using early and late spawned ova or controlling incubation temperature it is possible to have two through-puts of ova to alevin/parr in the one season. Care must be taken to ensure the efficient operation of the biofilters in these units and to prevent the influx of potential disease agents as treatments can be difficult to apply. To be viable it is essential that increases in production in these units at least offset the costs of their installation and operation.

A parallel development has been the introduction of polytunnel units whereby smolts are produced in tanks under cover. Polytunnels allow a greater degree of control of the rearing environment and generally provide farmers with much improved working conditions compared with the traditional outdoor (open-air) units. In both outdoor and polytunnel units there has been an increasing use of remote sensors and computerised control of operations. It is envisaged that there will be increases in the number of high-tech and polytunnel units in operation and in the computerised control of smolt production in general.

Ova production

TABLE 16
Number of ova (000s) produced in 1991/92 -1995/96 spawning periods

Year	1991/1992	1992/1993	1993/1994	1994/1995	1995/1996
No of ova	118,432	93,517	98,900	89,556	122,665

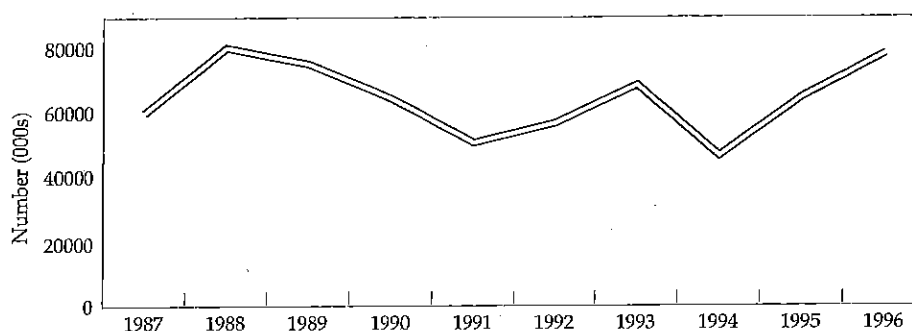
As spawning extends over October to January the data given here relate to spawning periods rather than to the calendar year. The total number of ova produced in 1995/96 was 122.7 million and was an increase of 33.1 million (37%) on 1994/95 figure.

TABLE 17
Ova sources and number of ova (000s) laid down to hatch in 1991/2-1995/1996

Year	Own stock	Other GB farm stock	GB wild	Foreign	Total	Previous year estimate
1991-92	32,824	23,722	310	-	56,857	-
1992-93	44,524	19,281	514	4,381	68,699	54,415
1993-94	25,883	14,991	450	5,347	46,672	49,064
1994-95	37,176	25,063	475	2,160	64,873	46,538
1995-96	46,545	23,784	65	8,045	78,439	71,635
1996/7	-	-	-	-	-	76,629

The total number of ova laid down to hatch in 1995/96 increased by 13.5 million(21%) to 78.4 million, an increase of 6.8 million on producers' forward estimate made in 1994/5. This increase was achieved despite fears of possible low fecundity following the unusually warm summer in 1995. There was a significant increase in the number of ova derived from producers' own stock whilst supplies from other GB sources decreased slightly. Imports from foreign sources increased fourfold in 1996 compared with 1995, Producers' forward estimate for ova to be laid down to hatch in 1996/97 was 76.6 million.

Numbers of ova laid down for hatching in 1987-1996



International trade in ova

Since the introduction of the EU Single Market on 1 January 1993 and the associated Fish Health Regulations common to all Member States, a trade in live salmon and ova has been established. Trade with Third Countries has also been established but imports are permitted only under licence and from sources of equal or higher health status to those of GB. Exports to Third Countries are at the discretion of the Third Country. The Marine Laboratory Aberdeen advises potential exporters to ascertain with the importing country well in advance of the spawning season if any specific fish health testing regimes may be a condition of export.

IMPORTS

TABLE 18a
Number and sources of salmon imports in 1993-1996

Source of import	No of ova imported			
	1993	1994	1995	1996
OVA				
EU Member States	4,439,000	5,823,400	1,470,000	6,690,000
Australia	470,000	240,000	600,000	1,355,000
SMOLT & PARR				
Parr	-	72,000	2,662,000	415,000
Smolt	-	-	-	2,138,000

Imports of ova increased by 6 million in 1996. Ova sources in The Republic of Ireland were again able to meet demand and imports from this source increased fourfold. "Out of season" ova from Australia doubled although the number imported remained relatively small, comprising <2% of ova laid down to hatch. Imports of smolts were first recorded in 1996, all coming from Irish sources. In addition a small number of parr and a few broodfish were imported from Ireland.

EXPORTS

TABLE 18b
Numbers (000s) of salmon ova of exported in 1993-1996

Spawning period	Export year	Farmed Origin			Total	Wild origin Total
		Chile	EU	Others		
1993	1994	9,467	7,540	40	17,047	450
1994	1995	22,691	7,242	40	31,833	450
1995	1996	17,542	7,937	20	25,499	635
1996	1997	28,585	13,729	-	42,314	635

Provisional figures only for 1997

The export data in Table 18b include ova spawned in October-December the previous year ie. exports in 1996 include ova spawned in 1995, in 1997 for ova spawned in 1996 etc. To date, in 1997, 42.3 million ova have been exported from the 1996 spawnings, approximately 11 million (66%) more than in 1996. Chile was again the main market with exports increasing by 11 million (63%) to 28.6 million compared with 17.5 million in 1996. Within the EU the Republic of Ireland was the major recipient market. Trade in wild fish ova was targetted at restocking European river systems.

In this reporting year (1996) approximately 122 million ova were produced (in October-December 1995); of these 70 million (57%) were laid down to hatch, 25 million (20%) exported and the remaining 27 million (22%) discarded. The export market has served as a stimulus for increased ova production in recent years but its future is uncertain as overseas producers may become self-sufficient in ova supply. The increase in ova exported has reflected the quality and demand for Scottish salmon ova on the world market.

In 1995 374,000 parr were exported, there were no parr exports in 1996.

Ova and smolt production records

TABLE 19
Ova laid down to hatch and smolt production records and estimates in 1987-1998

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Ova (million) laid down to hatch												
Number laid down ¹	60.1	80.4	75.3	64.6	50.7	56.9	68.7	46.7	64.9	78.4	-	-
Estimated number	58.6	67.5	85.1	90.8	50.4	60.4	54.4	49.1	46.5	71.6	76.6	-
Smolt production (million):												
Smolts produced ²	13.3	22.5	25.8	24.9	22.4	20.8	21.0	23.1	26.5	33.6	-	-
Smolts put to sea ¹	12.9	20.9	23.8	21.4	20.3	20.5	20.5	22.0	26.8	30.8 ³	-	-
Estimated smolts produced ²	15.2	23.1	28.7	26.2	24.1	21.5	21.8	22.1	25.2	31.8	41.6	48.9
Ratio of ova laid down to smolts produced ⁴	4.5	3.6	2.9	2.6	2.3	2.7	3.3	2.0	2.4	2.3	2.1	-

¹ Salmon growers' data; ² Smolt producers' data; ³ excludes 2.1 million smolts imported from Ireland; ⁴ based on number of smolts produced

Over 1987-1996 the number of ova laid down to hatch each year has ranged from 46.7 to 80.4 million whilst the number of smolts produced has ranged from 13.3 to 33.6 million. Since 1992 the number of ova laid down and the number of smolts produced has increased progressively from 56.9 to 78.4 million and 20.8 to 33.6 million respectively. Increases of 10 and 7 million in smolt production are estimated for 1997 and 1998. In 1996 there was a discrepancy of 2.8 million (9%) between the number of smolts produced (smolt producers data) and the number of smolts put to sea (salmon growers data). Such discrepancies are not uncommon and tend to be due to variations in the accuracy of the counters and counting methods employed.

The ratio of ova laid down to hatch and smolts produced was 2.1 in 1996, a slight improvement on the 1994 and 1995 figures. An estimated 5-10% mortality occurred at the hatching and first feeding stages but the greatest mortality is due to culling caused by inadequate growth in the first summer. Increased survival from ova to smolt is an area that should be addressed with a regard to increasing overall efficiency. Further improvements in growth between egg and parr stages are clearly desirable to reduce the need to cull.

Scale of production

TABLE 20
Number of smolt producing sites grouped in relation to the number(000s) of smolts produced in 1987-1996

Year	1-10	10-	26-	51-	101-	251	501-	>1,000	No of sites in production	Total smolts produced
		25	50	100	250	-500	1,000			
1987	45	18	16	20	16	10	5	1	131	13,294
1988	6	18	23	28	30	13	12	1	131	22,499
1989	7	18	20	16	37	20	10	3	131	25,825
1990	3	15	19	20	29	19	9	4	118	24,874
1991	2	11	17	22	26	26	5	2	111	22,404
1992	3	8	14	17	41	23	4	0	110	20,828
1993	1	9	15	17	32	21	9	0	104	21,043
1994	4	5	13	24	37	17	13	0	113	23,117
1995	1	6	15	29	30	26	14	1	122	26,540
1996	1	7	13	29	33	26	17	3	129	33,619

The data in Table 20 refer only to sites producing smolts, sites holding only ova, fry and/or parr are excluded. Overall the number of smolt producing sites in 1996 increased by 7. Since 1987 however there has been a significant reduction in the number of sites producing 50,000 or less smolts annually whilst the numbers of sites producing in excess of 250,000 smolts has increased. It is likely that this trend will continue as more high-tech recirculation units are constructed.

Ova and smolt production by Region

TABLE 21

Number of staff, ova laid down to hatch and smolt production by Region in 1995-1996 and estimated in 1997 and 1998

REGION	Number of staff employed in 1996		Ova laid down to hatch (000s)		Smolt production (000s)		Estimated smolt production(000s)	
	F/T	P/T	1995	1996	1995	1996	1997	1998
Highland	111	61	36,127	35,823	13,449	16,735	22,346	23,745
Orkney	7	5	1,200	750	501	286	555	640
Shetland	22	15	4,316	5,070	947	1,364	2,905	4,410
Strathclyde	76	32	9,553	21,340	5,222	8,439	8,623	9,610
Western Isles	70	14	10,342	10,666	5,127	5,135	5,810	7,440
Combined ¹	22	6	3,335	2,980	1,294	1,660	1,337	1,970
All Scotland	308	133	64,874	78,439	26,540	33,619	41,576	47,815

¹Includes Central, Dumfries & Galloway, and Tayside Regions - there was no production in Grampian or Borders Regions.

Highland Region followed by Strathclyde, Western Isles and Shetland were the principal ova and smolt producing Regions and employed the greatest numbers of staff. The number of ova laid down in 1996 was broadly similar to 1995 except in Strathclyde where the total number of ova laid down more than doubled. Strathclyde Region also reported a 60% increase in the number of smolts produced in 1996. In terms of productivity Highland Region was the most efficient producing 97,000 smolts per man. Production figures at Orkney were low due to one site ceasing to operate and to problems with broodstock at stripping time. All Regions anticipate increases in smolt production in 1997 and 1998. Anticipated smolt production at Shetland in 1998 is 4.4 million; this is quadruple the production in 1995 and reflects local investment geared at making Shetland more self-sufficient in smolt supply.

TABLE 22

Number of sites using vaccines and number of fish vaccinated in 1986-1996

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
No of sites	3	8	29	65	59	61	71	73	85	102	112
No of fish vaccinated (million)		-	-	-	-	-	-	-	19.4	25.3	31.8

The number of sites using vaccines to give protection against the bacterial disease furunculosis, caused by the bacterium *Aeromonas salmonicida*, increased by 10 to 112 and the number of smolts vaccinated increased by 6.5 million to 31.8 million compared with 1995. This was equivalent to 95% of the total smolt production and showed farmers' keen awareness of the advantages of using and the efficacy of vaccines in combating disease. Mostly monovalent vaccines, designed specifically to combat furunculosis were used but polyvalent vaccines were used on a number of sites.

TABLE 23

Number (000s) of fry and parr moved between sites in 1992-1996

Year	Number (000s) of fry and parr moved	
	Into sites	Out of sites
1992	32,018	29,444
1993	33,330	30,778
1994	32,478	29,648
1995	42,462	39,211
1996	53,423	37,672

The numbers of fry and parr moved onto sites increased by 11 million (26%) continuing the uptrend evident since 1994. The decrease in the movement of fry and parr offsite suggested that these fish tended to be held on ongrowing sites after their initial transfer ex-hatchery.

B. Production fish (Atlantic Salmon)

Production

Annual production in Atlantic salmon is given as the combined tonnage of all age groups harvested in a calendar year. Trends in production by year class and category are shown in Tables 24a-d.

TABLE 24a
Weight of salmon (tonnes) harvested annually in 1985-1996 and estimated in 1997

Year	Tonnes	Year	Tonnes
1985	10,337	1991	40,593
1986	10,337	1992	36,101
1987	12,721	1993	48,691
1988	17,951	1994	64,066
1989	28,553	1995	70,060
1990	32,351	1996	83,121
		1997	100,110

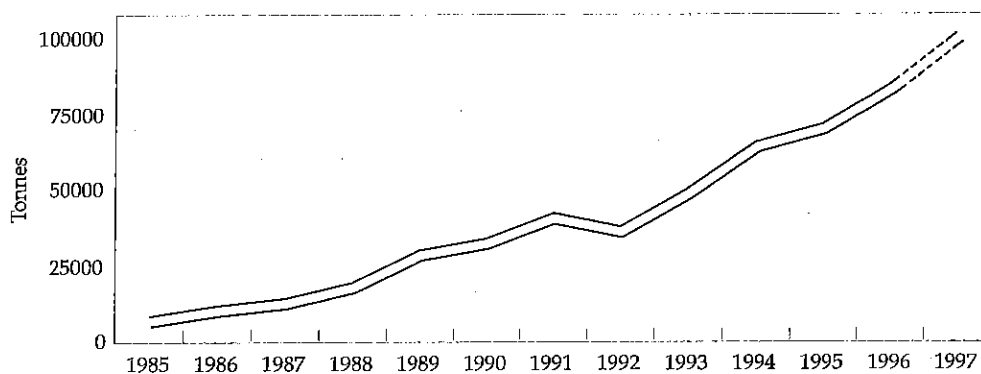


TABLE 24b
Number (000s) and weight (tonnes) of salmon harvested and mean fish weight (kg) per smolt year class in 1993-1996

	Year of smolt input	Year of harvest	Production		
			Number (000s)	Tonnes	Mean weight (kg)
Harvest in year 0 (ie. in year of input)	1993	1993	47	78	1.7
	1994	1994	261	388	1.5
	1995	1995	207	369	1.8
	1996	1996	315	638	2.0
Harvest in year 1	1992	1993	11,102	32,738	3.0
	1993	1994	13,446	41,865	3.1
	1994	1995	14,420	47,775	3.3
	1995	1996	17,132	57,998	3.4
Harvest in year 2	1991	1993	4,675	15,975	3.4
	1992	1994	5,096	21,812	4.3
	1993	1995	5,137	21,916	4.3
	1994	1996	5,408	24,485	4.5

Total production of salmon in Scotland has increased annually since 1992. Production in 1996 was 83,181 tonnes, an increase of 13,0161 tonnes (19%) on the 1995 figure. Increases were reported in the number and weight harvested and in mean fish weight in all age groups. 1-year old fish comprised 70% by weight of production and reflected market demand for fish in the 3-4kg size range. The harvest in the year of input (year 0) of young, small fish although still small was almost doubled and mean fish weight increased by 0.2 kg. The harvest of these fish was advantageous in that it allowed farmers to meet a specific market requirement whilst simultaneously reducing stocking densities. As in previous years larger fish tended to go for smoking.

TABLE 24c
Weight (tonnes) and number (000s) of grilse and pre-salmon harvested annually in 1993-1996

Year	Grilse (Jan - Aug)			Pre-salmon (Sep - Dec)		
	Number (000s)	Tonnes	Mean weight(kg)	Number (000s)	Tonnes	Mean weight (kg)
1993	4,969	12,739	2.6	6,133	19,999	3.3
1994	6,435	17,386	2.7	7,011	24,479	3.5
1995	7,610	22,235	2.9	6,809	25,540	3.8
1996	8,669	25,776	3.0	8,462	32,222	3.8

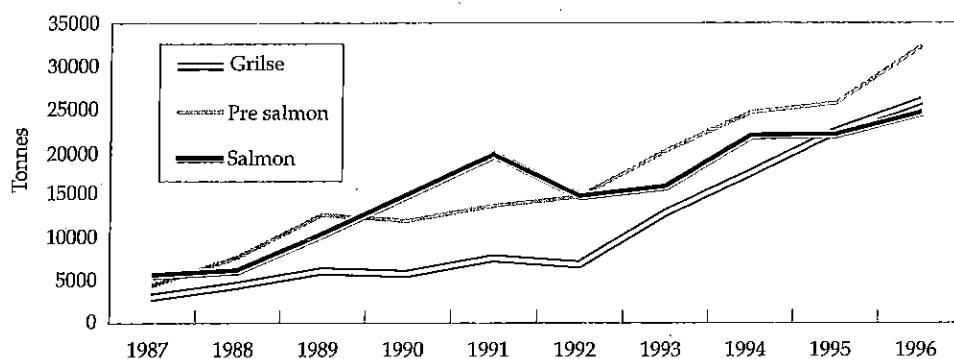
TABLE 24d
Proportion of annual production (% weight) by growth stage in 1993-1996

Year	1993	1994	1995	1996
Input year fish	<1	<1	<1	<1
Grilse	26	27	32	31
Pre-salmon	41	38	37	39
Salmon	33	34	31	29

Production in 1-year old fish was recorded separately for the periods January- August, to cover the traditional grilse period (grilse), and September-December for non-maturing fish (pre-salmon). All 2-year old fish were classed as salmon. The numbers of grilse and pre-salmon harvested in 1996 were approximately equal and showed farmers ability to produce fish of specific size throughout the year. Modest increases in mean fish weight was recorded in both groups with pre-salmon weighing on average 0.8kg more than grilse.

The increase in total production was achieved due to a combination of on-going improvements in feedstuffs and feeding methods; improvements in husbandry practices, particularly those aimed at reducing stress; the effectiveness of vaccines in controlling disease; the size of smolt and time when put to sea and the application of group management schemes covering single age group stocking over extended areas, fallowing and stocking with smolts of common health status. The effect of environmental factors on growth were difficult to quantify in consideration with the above and that production was geared to meet specific market requirements. One can but speculate as to what effect global warming might have on growth and production or disease in the future.

Production(tonnes) of salmon by age grouping in 1987-1996



Survival and production in smolt year classes

TABLE 25
Survival and production (harvest) in smolt year classes put to sea in 1984-1996⁵

Year of smolt input	Smolt input (000s)	HARVEST YEAR 0				HARVEST YEAR 1				HARVEST YEAR 2				Total % of year class harvested	Year class weight (tonnes)
		Number (000s)	Weight (tonnes)	Mean weight (kg)	% Harvested	Number (000s)	Weight (tonnes)	Mean weight (kg)	% Harvested	Number (000s)	Weight (tonnes)	Mean weight (kg)	% Harvested		
1985	5,586	-	-	-	-	2,409	5,988	2.5	43.1	1,522	5,521	3.7	27.3	70.4	11,508
1986	6,595	-	-	-	-	3,285	7,200	2.1	49.8	1,750	6,086	3.5	26.5	76.3	13,286
1987	12,858	-	-	-	-	5,167	11,866	2.3	40.2	3,267	10,312	3.2	25.3	65.5	22,178
1988	20,921	-	-	-	-	7,890	18,240	2.3	37.7	5,382	14,891	2.8	25.7	63.4	33,131
1989	23,839	-	-	-	-	7,683	17,459	2.3	32.2	6,123	19,567	3.2	25.7	57.9	37,026
1990	21,408	-	-	-	-	8,877	21,026	2.4	41.5	4,315	14,728	3.4	20.1	61.6	35,754
1991	20,227	-	-	-	-	8,864	21,373	2.4	43.8	4,675	15,875	3.4	23.1	66.9	37,248
1992	20,527	-	-	-	-	11,102	32,738	3.0	54.1	5,096	21,812	4.3	24.8	78.9	54,550
1993	20,541	46	78	1.7	0.2	13,446	41,865	3.1	65.5	5,135	21,916	4.2	25.0	90.7	63,859
1994	21,953	260	388	1.5	1.2	14,420	47,775	3.3	65.7	5,408	24,485	4.5	24.6	91.5	72,629
1995	26,786	206	269	1.8	0.8	17,132	57,998	3.4	64.0	-	-	-	-	-	-
1996	32,906	315	638	2.0	1.9	-	-	-	-	-	-	-	-	-	-

Survival was defined as the number of smolts put to sea in one year (smolt input year class) and surviving to harvest. In the last year for which smolt survival can be calculated, 1994, survival was 91.5%, the highest ever recorded and continued the upward trend evident since 1990. Approximately 65% of the 1995 year class was harvested as 0- or 1-year old fish, slightly down on the proportions reported for the 1993 and 1994 year classes. Potential production from the 1995 year class in 1997 can be calculated if it is assumed that a similar proportion of the year class (24.6%) of similar mean fish weight (4.5kg) will be harvested as 2-year old fish in 1997 as for the 1994 year class harvested in 1996. On this basis the 1995 year class can be expected to provide a harvest of 29,652 tonnes in 1997. Likewise for the 1996 year class if a similar proportion (64%) of similar mean weight (3.4kg) as in the 1995 year class harvested in 1996 is harvested in 1997, a harvest of 71,603 tonnes can be expected in 1997. Also assuming that 700 tonnes of the 1997 year class will be harvested as 0-year old fish in 1997, total production in 1997 is expected to exceed 101,955 tonnes. Farmers forward estimate of production in 1997 is 100,110 tonnes.

Smolts to sea

TABLE 26
Number (000s) and origin of smolts put to sea in 1992-1996

Year	Smolts to sea (000s)				Total (000s)	England origin		Other origin	
	S ^{1/2}	S1	S1 ^{1/2}	S2		(000s)	%	(000s)	%
1992	-	19,418	-	1,109	20,527	992	5	-	-
1993	-	19,843	-	698	20,541	827	4	-	-
1994	1,865	19,701	113	274	21,953	1,451	7	-	-
1995	2,442	23,081	589	674	26,786	852	3	-	-
1996	5,527	26,157	180	974	32,906	1,166	4	2,138	6

The total number of smolts put to sea in 1996 was 32.9 million, an increase of 6.12 million (23%) on 1995. As in previous years the majority of smolts put to sea were S1s (26 million, 79%). The number of smolts put to sea in 1996 as S^{1/2}s (5.5 million, 17%) was more than double that in 1995 and showed farmers keen awareness of the advantages of year round stocking to meet year round market demand for fish of specific size. The small input of older smolts (S1^{1/2} and S2) reflected the small numbers of these age groups produced. Approximately 4% of smolts put to sea in 1996 came from English sources, these were predominantly of Scottish origin. The first import of smolts of Irish origin took place in 1996 when 1 million S^{1/2}s and 1.1 million S1s were imported.

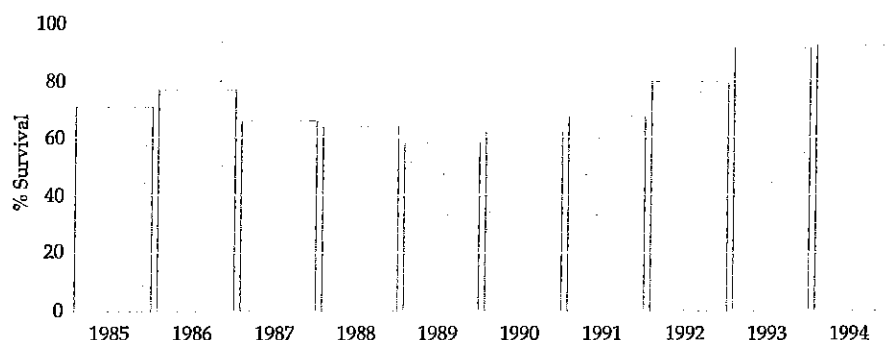
Survival and production in smolt year classes by Region

TABLE 27
Number (000s) of smolts put to sea, year class survival and total production (tonnes) by Region in 1991-1996

Region	Smolts to sea (000 s)		Harvest in Year 0			Harvest in Year 1			Harvest in Year 2			Total harvest (= survival)	
	Year	No.	Year	No.	%	Year	No.	%	Year	No.	%	No.	%
Highland	1991	11,107	1991	-	-	1992	3,755	33.8	1993	1,730	15.6	5,485	49.4
	1992	7,650	1992	-	-	1993	5,160	67.5	1994	1,647	21.5	6,807	89.0
	1993	7,684	1993	47	0.6	1994	5,405	70.3	1995	1,927	25.1	7,379	96.2
	1994	7,914	1994	108	1.4	1995	4,721	59.7	1996	1,438	18.2	6,267	79.2
	1995	9,428	1995	60	0.6	1996	7,500	79.6	1997	-	-	-	-
	1996	12,438	1996	99	0.8	1997	-	-	-	-	-	-	-
	1997	-	-	-	-	-	-	-	-	-	-	-	-
Orkney	1991	746	1991	-	-	1992	236	31.6	1993	208	27.9	444	59.5
	1992	681	1992	-	-	1993	236	34.7	1994	217	31.9	453	66.6
	1993	726	1993	-	-	1994	478	65.8	1995	176	24.2	654	90.0
	1994	754	1994	-	-	1995	399	52.9	1996	222	29.4	621	82.3
	1995	1,127	1995	-	-	1996	508	45.1	1997	-	-	-	-
	1996	1,175	1996	-	-	1997	-	-	-	-	-	-	-
	1997	-	-	-	-	-	-	-	-	-	-	-	-
Shetland	1991	4,643	1991	-	-	1992	2,012	43.3	1993	1,135	24.4	3,147	67.8
	1992	5,014	1992	-	-	1993	2,342	46.7	1994	1,248	24.9	3,590	71.6
	1993	4,591	1993	-	-	1994	3,354	73.1	1995	993	21.6	4,347	94.7
	1994	5,012	1994	24	0.5	1995	3,055	61.0	1996	1,846	36.8	4,925	98.3
	1995	5,811	1995	41	0.7	1996	3,021	52.0	1997	-	-	-	-
	1996	6,234	1996	-	-	-	-	-	-	-	-	-	-
	1997	-	-	-	-	-	-	-	-	-	-	-	-
Strathclyde	1991	4,597	1991	-	-	1992	1,355	29.5	1993	981	21.3	2,336	50.8
	1992	3,989	1992	-	-	1993	1,667	41.8	1994	1,182	29.6	2,849	71.4
	1993	5,131	1993	-	-	1994	2,300	44.8	1995	1,215	23.6	3,515	68.5
	1994	4,614	1994	-	-	1995	2,994	64.9	1996	1,460	31.6	4,454	96.5
	1995	6,437	1995	25	0.4	1996	3,268	50.8	1997	-	-	-	-
	1996	9,924	1996	64	0.6	1997	-	-	-	-	-	-	-
	1997	-	-	-	-	-	-	-	-	-	-	-	-
Western Isles	1991	2,946	1991	-	-	1992	1,506	51.1	1993	620	21.0	2,126	72.2
	1992	3,195	1992	-	-	1993	1,742	54.5	1994	802	25.1	2,544	79.6
	1993	2,805	1993	-	-	1994	1,909	68.1	1995	825	29.4	2,734	97.5
	1994	4,002	1994	125	3.1	1995	3,252	81.3	1996	442	11.0	3,819	95.4
	1995	3,983	1995	80	2.0	1996	2,836	71.2	1997	-	-	-	-
	1996	5,137	1996	152	3.0	1997	-	-	-	-	-	-	-
	1997	-	-	-	-	-	-	-	-	-	-	-	-

Although overall survival in the 1994 (91.5%) year class was the highest ever there was considerable variation between Regions. Increased survival was reported in Shetland and Strathclyde whilst decreases were reported in Highland, Orkney and Western Isles. In some instances large numbers of smolts were lost due to what is termed "fading smolt syndrome" which in general terms means that smolts fail to survive after transfer to sea for a variety of reasons, the main being that the smolts are unable to adapt fully to the marine environment. The severity of grading may also affect smolt year class survival. All Regions reported an increase in smolt input in 1996.

Total % survival in smolt year classes put to sea in 1985-1994



Staffing

TABLE 28
Number of staff employed in salmon production in 1987-1996

Year		1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Staff:	full time	608	991	1,102	1,165	1,014	985	976	1050	1104	1150
	part time	206	329	316	326	272	275	248	248	251	241
Total staff		806	1,320	1,418	1,491	1,286	1,260	1224	1,298	1355	1391

In 1996 the number of staff employed in salmon production increased by 36 compared with 1995. Full-time staff increased by 46 whilst part-time staff decreased by 10. The move to more full-time staff in general reflected the increase in tonnage produced. The above figures refer specifically to staff associated with the production of salmon and does not include staff associated with processing or marketing.

In recent years the nature of the work on salmon grower sites has altered as new technology such automatic feeding systems and monitoring of stocks using TV cameras etc. has been introduced. This increased usage of technology has given rise to specialist jobs which require a high degree of skill and knowledge. As more advanced technology and automation is introduced to the industry it is unlikely that there will be large increases in staffing levels despite forward estimates of further increases in production tonnages.

Production systems

TABLE 29
Production systems, capacity, tonnage and ratio of production (kgs) to capacity (m³) in 1993-1996

System of production	Number of sites				Total capacity (000s cubic metres)				Production (tonnes)			
	1993	1994	1995	1996	1993	1994	1995	1996	1993	1994	1995	1996
Sea water tanks	7	5	5	5	46	23	23	23	668	532	598	490
Sea water cages	276	257	263	272	6,482	6,669	7,313	8,433	48,023	63,534	69,462	82,631
For cage sites: Ratio of production (kgs) to cage capacity (m ³)									7.4	9.5	9.5	9.8

There are 2 systems employed in the production of salmon, namely seawater cages and land based tanks using pumped seawater. A total of 82,631 tonnes (99%) was produced in seawater cages with only 490 tonnes (1%) being produced in tanks. The small number and low production from tank sites was a reflection of the relatively high energy costs incurred in operating this system compared with the cage system.

Sea cage capacity increased by 1.1 million cubic meters in 1996 and was due to a greater number of sites being in production and to increases in cage size. Large circle cages, supporting nets measuring 100m circumference x 22 meters depth, have become increasingly popular in Scottish waters. Production efficiency in cages, measured as the ratio of kilograms produced to cubic meter cage capacity, increased by 0.3kg in 1996.

Productivity

TABLE 30
Productivity (tonnes/man) by companies grouped by scale of production in 1996

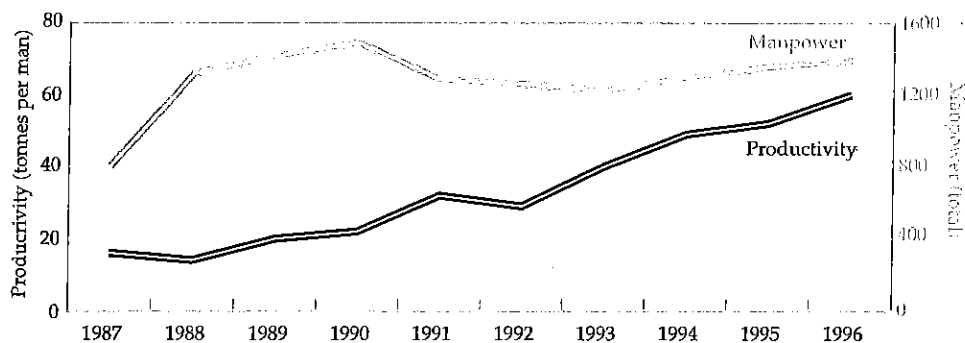
Total tonnage	0-100	101-200	201-400	401-700	701-1000	1001-2000	<2,000	Total
No companies	28	17	25	12	10	9	6	120
No. tonnes	1,073	2,551	7,445	6,434	8,176	13,445	43,997	83,121
Manpower (PT)	42	28	42	54	11	39	25	241
(FT)	62	65	126	105	113	157	522	1,150
Manpower (total)	105	83	168	159	124	196	547	1,391
Productivity (tonnes/man)	10	31	44	40	66	69	80	60
Range in production (tonnes/man)	2-100	14-55	28-146	13-181	35-182	30-174	53-260	-

FT = Full time, PT = Part time

Productivity was estimated by relating the production tonnage to the manpower employed. It was evident that small producer companies (<200 tonnes) tended to employ proportionally more part-time staff than the larger producer companies.

Mean productivity in 1996 was 60 tonnes per man and was significantly greater than the 52 tonnes per man recorded in 1994 and 1995. Productivity in the larger producer companies (>700 tonnes) was greater than in the small producer companies, a trend which has been evident for some years and has been due principally to the large producers having the capital to expand their field of operations and to invest in advanced rearing technology, as was demonstrated in the company which achieved a productivity of 260 tonnes per man in 1996. The absence of major disease problems has also contributed to the overall increases in productivity since 1993. In small producer companies productivity, as defined above, can be skewed to appear low depending on the number of sites operated and whether these sites were stocked, harvested or fallowed in any given year but the mean should even out such appearances. From the ranges in productivity it was evident that high levels of productivity could be achieved by small producer companies.

Manpower and productivity in salmon production 1987-1996



Manpower and Production by Region

TABLE 31
Manpower and production by Region in 1992-1996 and estimated production in 1997

Region	Year	Staff		Annual production	Production (t/man)	Year of Input		Grilse		Pre-salmon		Salmon	
		F/T	P/T			Tonnes	Mean wt (kg)	Tonnes	Mean wt (kg)	Tonnes	Mean wt (kg)	Tonnes	Mean wt (kg)
Highland	1992	372	63	13,980	32	-	-	3,352	2.2	5,791	2.6	4,837	3.3
	1993	372	52	20,279	48	78	1.7	7,177	2.5	7,225	3.2	5,800	3.4
	1994	407	59	25,003	54	170	1.6	7,392	2.7	9,991	3.7	7,450	4.5
	1995	401	54	22,509	49	99	1.6	7,291	2.7	7,433	3.6	7,686	4.0
	1996	405	45	32,282	72	200	2.0	14,824	3.1	10,789	3.9	6,469	4.5
	1997			32,851									
Orkney	1992	35	21	1,046	19	-	-	163	2.4	412	2.4	471	2.8
	1993	38	16	1,245	23	-	-	212	2.3	428	3.0	605	2.9
	1994	48	19	2,107	31	-	-	371	2.5	957	3.0	780	3.6
	1995	58	11	1,903	28	-	-	392	2.7	849	3.4	662	3.8
	1996	55	13	2,444	36	-	-	511	2.5	1,023	3.3	910	4.1
	1997			3,543									
Shetland	1992	213	96	10,679	34	-	-	851	2.6	4,636	2.8	5,192	3.9
	1993	191	116	11,659	38	-	-	1,246	2.6	6,013	3.2	4,400	3.9
	1994	193	106	14,278	48	23	1.0	3,371	2.6	5,967	2.9	4,918	3.9
	1995	201	109	15,523	50	59	1.4	4,204	3.2	6,908	3.9	4,352	4.4
	1996	209	114	19,710	61	-	-	2,042	2.8	8,814	3.9	8,854	4.8
	1997			24,009									
Strathclyde	1992	206	46	6,458	26	-	-	1,154	2.0	2,108	2.7	3,196	3.2
	1993	199	32	8,675	38	-	-	2,107	2.8	3,366	3.7	3,202	3.3
	1994	173	35	13,184	63	5	1.0	3,277	2.8	4,249	3.8	5,653	4.8
	1995	247	51	15,777	53	47	1.9	4,641	3.0	5,505	3.8	5,584	4.6
	1996	273	44	17,223	54	68	1.1	3,889	2.8	6,895	3.7	6,371	4.4
	1997			20,637									
Western Isles	1992	159	49	3,938	19	-	-	1,203	1.8	1,703	2.1	1,032	2.7
	1993	176	32	6,834	33	-	-	1,998	2.5	2,968	3.1	1,868	3.0
	1994	182	23	9,493	46	191	1.5	2,976	2.7	3,316	4.2	3,011	3.8
	1995	197	26	14,348	64	164	2.0	5,707	2.9	4,845	3.8	3,632	4.4
	1996	208	25	11,462	49	370	2.4	4,510	2.8	4,701	3.8	1,881	4.3
	1997			19,070									
All Scotland	1992	985	275	36,101	29	-	-	6,723	2.1	14,650	2.6	14,728	3.4
	1993	976	248	48,691	40	78	1.7	12,740	2.7	20,077	3.2	15,875	3.4
	1994	1,003	242	64,066	51	389	1.5	17,386	2.7	24,479	3.5	21,812	4.3
	1995	1,104	251	70,060	52	368	1.8	22,235	2.3	25,540	3.8	21,916	4.3
	1996	1,151	242	83,121	60	638	2.0	25,776	3.0	32,222	3.8	24,485	4.5
	1997			100,110									

Production within the Regions has tended to be governed by the availability of suitable marine grower sites, which is a function of Scotland's topography and the local hydrography. Highland Region continued to be the largest employer and produced the greatest tonnage of grilse, pre-salmon and salmon, with each category showing a significant increase in mean fish weight. Greatest productivity, 72 tonnes per man, was also achieved in Highland Region. Shetland, Strathclyde, and Western Isles ranked second, third and fourth in tonnage produced. Production, productivity and mean fish weight have fluctuated between Regions and over years and have tended to reflect the growing and harvesting strategy of the large producer companies rather than failures within the Regions. Overall the salmon industry has continued to be a major source of employment, particularly in many of the more remote areas of Scotland.

TABLE 32

Number of companies and sites engaged in salmon production in 1992-1996

Year	Number of companies			Number of sites		
	Producing	Non-producing	Total	Producing	Non-producing	Total
1992	140	6	146	279	68	347
1993	132	12	144	283	86	369
1994	119	12	131	262	101	363
1995	108	12	120	268	91	359
1996	106	1	107	278	56	334

A total of 107 salmon producer companies were registered with the Marine Laboratory Aberdeen, 13 less than in 1995. The number of companies actively producing salmon was 106, 1 less than in 1995. These data are somewhat misleading in that they include a number of satellite companies which had been bought over but the company name and registration was retained by the parent company for business reasons. Also included are a number of companies which had entered into contract growing arrangements, either in full or in part and which operate under their own name but may be under the control of the contracting company. Overall the industry was dominated by a small number of large producer companies, the 5 largest of which accounted for more than 60% of production in 1996. In recent years there has been a noticeable increase in the number Scottish companies coming under foreign ownership.

A total of 432 salmon grower sites were registered with the Marine Laboratory Aberdeen. Of these 334 sites were recorded as being Active, which included sites that were stocked but had no production tonnage in 1996 and the 56 sites reported fallow. The remaining 98 sites were registered as Inactive. A large number of the latter were sites which experience had shown to be unsuitable for the successful rearing of salmon for a variety of reasons and were unlikely to be used in the near future but are still retained on the official Register of Sites.

Fallowing

TABLE 33

Number of sea cage sites employing a fallow period in 1993-1996

Year	0	Fallowing period (weeks)					Total
		<4	4-8	8-26	26-51	≥52	
1993	135	7	47	74	13	86	362
1994	118	13	48	64	12	103	358
1995	110	14	60	73	6	91	354
1996	112	12	71	70	13	56	334

Of the 344 sites that were part of a production cycle, 56 were fallow throughout 1996, 166 were fallow for a variable period whilst the remaining 112 were stocked throughout the year. The normal duration of a growing cycle in seawater is up to 2-years and the introduction of a fallow period, when all nets and fish are removed, serves as a method of cleaning/resting sites.

The survey questionnaire did not distinguish how many of the 112 sites not fallowed held one or more year classes although it is understood that single year class stocking was common practice.

The Marine Laboratory Aberdeen strongly advises farmers:

- a) to incorporate a fallow period between growing cycles to break any cyclical disease that might be present
- b) the fallowing period should be as long as possible
- c) sites using shared waters (eg. where there are 2 or more sites in a sea loch or voe) should be stocked in the same year and have a common fallow period; where 2 or more such sites are used by different companies a formal agreement to achieve this type of stocking should be set in place.

Scale of production by site

TABLE 34
Grouping of salmon production sites in relation to tonnage produced in 1992-1996

Production grouping (tonnes)	Number of sites per production grouping							Total		
	0	1-50	51-100	101-200	201-500	501-1000	>1000	Sites	Tonnes	
No of sites	1992	139	55	48	46	43	15	1	347	36,101
	1993	144	53	44	50	61	10	7	369	48,691
	1994	154	29	31	49	64	27	9	363	64,066
	1995	162	24	23	37	68	32	13	359	70,060
	1996	125*	20	28	49	66	25	21	334	83,121
	% share of production	1992	0	4	10	20	37	27	3	-
	1993	0	3	7	14	38	19	18	-	-
	1994	0	1	4	12	33	31	19	-	-
	1995	0	1	2	8	31	32	26	-	-
	1996	0	1	3	9	27	22	39	-	-

* Includes sites stocked in 1996 but having no production.

There has been a distinct trend by companies to concentrate and increase production at individual sites. This has been evident since 1992 with the number of sites producing less than 50 tonnes having decreased year on year. Conversely there has been a significant increase in the number of sites producing in excess of 1000 tonnes per annum during the same period. The size of a site is determined by the biomass of fish permitted to be held as set in the Discharge Consent granted by SEPA (Scottish Environmental Protection Authority). Discharge Consents serve as a management tool in maintaining acceptable environmental standards in the vicinity of fish farms. It is likely that the trend towards sites being stocked at or near maximum level will continue. The concentration of production onto fewer larger sites has obvious economic benefits for producer companies but is not without risk. It is particularly important that health standards are maintained as the spread of an infectious disease could result in a major financial loss.

The Marine Laboratory Aberdeen continues to advise farmers that the currently highly effective controls on disease are more likely to fail as stocking densities increase.

Broodstock sites

TABLE 35
Number of sites holding broodstock in 1985-1996

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Broodstock sites	38	35	31	44	35	27	15	21	24	18	28

The number of sites holding broodstock, including freshwater and seawater stripping sites, in 1996 was 28. This was an increase of 10 the 1995 figure was related primarily to more brood fish being held and to specific stocks, such as low grilising or early/late spawning stocks, being held at separate sites as part of selective breeding programmes.

A total of 27,300 fish were stripped to yield 122.8 million ova. If a sex ratio of 1 male to 2 females at fertilisation is assumed, mean ova production per female was 13,500. Mean ova production in 1994/95 was 9,700 ova. As ova production tends to increase in relation to fish size and age and these data were not included in the survey, no comment can be made on differences in ova production between years.

CONCLUSIONS ATLANTIC SALMON

Large increases in production were recorded in all sectors of the salmon growing industry in 1996. The harvest of production fish was at an all time high and is estimated to be even greater in 1997. Productivity (tonnes/man) was also greater and reflected an increase in use of automation and technology plus other efficiencies in husbandry. The maximum level of productivity reported was some four times greater than the mean figure and indicated room for further improvement within the industry. In terms of employment salmon rearing was of significant importance to remote communities on the west coast and islands of Scotland. Salmon lice continued to require costly treatments in manpower terms on many sites in order to keep this health problem under control.

Survival of the 1993 and 1994 smolt year classes was in excess of 90% and similar or higher values can be expected from the 1995 and 1996 year classes. The numbers of smolt put to sea in 1996 were 23% greater than in 1995 and increases of similar magnitude are forecasted for 1997 and 1998. Any increase in salmon production resulting from these increased smolt inputs will be additional to other gains in growth derived from improvements in feedstuffs or technology. Disease, the most common cause of poor survival in the past, has in general either been absent on most sites or under control. Due to industry and insurers experience losses due to storm damage were relatively small.

Considerable effort was devoted to producing smolts for year round stocking of sea sites. Although S1 smolts continued to dominate there was a large increase in the numbers of S1/2 smolts produced. The introduction of high tech, high density and polytunnel smolt rearing units giving producers added ability to manipulate the smolt growing environment contributed to the increase in smolt production. Stocking densities in tanks increased by 36% and in cages by 9%. Stocking density in tanks was approximately five times greater than in cages. Experience has shown however that the use of recirculated water in smolt production is not without danger and operators must ensure that high health standards are maintained at all times.

Salmon growers tended to favour northern hemisphere photoperiod adapted smolts rather than smolts derived from "out of season" southern hemisphere ova. Imports of smolts from Ireland, first recorded in 1996, are likely to continue as salmon grower companies expand their fields of operation across national boundaries. The export market for ova continued to expand and was a target market for a number of companies. Chile was again the main recipient market. The marketing of ova within EU states was established following the introduction of the EU Single Market in 1993 but the level of trade here has become dependent on the rearing strategies of the large multi-national salmon grower companies.

The trend within the industry as a whole has been one of increasing production and forecasts are that these increases will continue. Although not part of the survey the Marine Laboratory Aberdeen is well aware that the market price for salmon has been decreasing in recent years and that the increases production have not been matched by equivalent increases in profitability. This has been of great concern to salmon growers and has been a major factor in determining their modes of operation.

ALS Munro
JA Gauld
May 1997

Appendix 1

**ANNUAL RETURN OF INFORMATION FROM SCOTTISH FISH FARMS
FOR THE PERIOD 1 JANUARY TO 31 DECEMBER 1996**

RAINBOW TROUT - DATA

Please complete and return by 10 January 1997 to J Gault, SOAEFD Marine Laboratory
PO Box 101, Victoria Road, Aberdeen, AB9 8DB

Reg No SF/

Name of site Please correct site name here Please correct main method of production on each site (if
(if necessary) (if necessary)

1 **How many staff were employed in trout production** Full time Part time
(company total)

Site 1 Site 2 Site 3 Site 4

2 **How many eyed ova were laid down**
for hatching in 1996
a from own broodstock
b from GB broodstock

c from abroad (Northern Hemisphere
including N Ireland and Isle of Man)

d from abroad (Southern Hemisphere)

3 **How many of the above ova were**
a all female diploid
b mixed sex diploid
c all triploid

4 **How many fry/fingerlings were**
a bought
b sold

5 **How many bought fry/fingerlings were**
a all female diploid
b mixed sex diploid
c all triploid

6 **How many of these fish were**
vaccinated against ERM
a on site
b bought vaccinated

7 **What was your total production in**
TONNES for the TABLE TRADE
a <450 g (<1 lb)
b 450-900 g (1-2 lb)
 >900 g (>2 lb)

8 **What was your total production in**
TONNES for the RESTOCKING
TRADE
a <450 g (<1 lb)
b 450-900 g (1-2 lb)
c >900 g (>2 lb)

